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OPERATION KNOTHOLE

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PROJECT SUMMARIES

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By [redacted] Date [redacted]

NEVADA PROVING GROUNDS

SPRING 1953

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MILITARY RESEARCH & APPL.

[redacted]

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OPERATION KNOTHOLE

20279

PROJECT SUMMARIES

Compiled By

OFFICE OF THE TECHNICAL DIRECTOR
DIRECTORATE OF WEAPONS EFFECTS TESTS
FIELD COMMAND
AFSWP

[redacted] RESTRICTED DATA [redacted]

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Chief, ISTS

Date: 3/13/95

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[redacted] SECURITY INFORMATION

FOREWORD

12 December 1952 20279

Since the submission to the Research and Development Board of the original outline of DOD experiments to be conducted in Operation UPSHOT/KNOTHOLE, many additions, deletions and modifications have been witnessed. It is the purpose of this publication to present an up-to-date outline of the DOD experiments contemplated for the operation.

It is requested that this publication be accepted for simply its stated purpose. The course of scientific experimentation is characterized by change, and more changes in the program are expected before shot time, approximately three months hence. Changes subsequent to this publication will be reflected in the post shot reports of the Operation.

H. K. GILBERT
Colonel, USAF
Deputy Technical Director

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PROGRAM I

BLAST AND SHOCK MEASUREMENTS

LCDR WL CARLSON, USN

PROGRAM DIRECTOR

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Project Number: 1.1a

Title: Basic Air Blast Measurements

Sponsor: AFSWP

Performing Agency: Naval Ordnance Laboratory

Project Officer: Dr. W. E. Morris, Civ.

Objective: To obtain pressure-time curves at various distances from ground zero and to determine the effects on the blast wave of a thermal absorbing and a thermal scattering smoke layer interposed between the bomb burst and the recording instruments.

Procedure: Wianko pressure gauge measurements will be made at ground level and at a 10 foot height along two blast lines. The measurements made on one line, which will be covered with a smoke blanket, will be compared with those made on the other (main) blast line.

This project will participate in the two (2) KNOTHOLE shots with a thermal scattering layer used on the first shot and a thermal absorbing layer on the second. The smoke blanket will be provided in conjunction with Project 8.4.

Remarks: None

[redacted] [redacted]

Project Number: 1.1b Title: Basic Air Blast Measurements

Sponsor: AFSWP Performing Agency: Stanford Research Institute under contract to Office of Naval Research

Project Officer: Mr. L. M. Swift, Civ.

Objective: To obtain pressure-time data vs ground range along with the Mach stem path on KNOTHOLE shots, and the effects of baffle orientation on pressure time curves. To determine by accelerations at 1 foot below ground if appreciable energy is transmitted just below ground level.

Procedure: Pressure-time relationships on earth acceleration will be measured by means of Wiancko pressure gauge set at 0, 10, 30, 40 and 50 foot elevations and Wiancko accelerometers at a depth of 1 foot deployed at various distances from ground zero.

From an analysis of the differences between the times of arrival of the incident and reflected shock waves at the various gauge heights the path of the triple point at each station can be determined. A similar analysis between the same gauge heights at different stations determine the path of the triple point between stations.

Remarks: This agency will obtain and analyze the majority of fundamental data for use in correlating data of other programs. Measurements are to be made on KNOTHOLE shots number 1 and 2 and 2 airdrops in the Yucca area.

[redacted]

Project Number: 1.1c Title: Basic Air Blast Measurements

Sponsor: AFSWP Performing Agency: Sandia Corporation

Project Officer: Dr. J. M. Harding, Civ.

[redacted]

Objective: To obtain pressure-time vs distance measurements.

To study the effects of terrain on blast pressures.

Procedure: Wiancko air blast gauges will be installed at ground level and 10 feet above ground at various distances from ground zero to obtain pressure-time vs distance information for a tower shot.

Wiancko gauges installed in ground baffles will be deployed on the surface of the ground near selected terrain features. These gauges will be between 14,000' and 19,000' from ground zero to study "hill and dale" effects in Yucca Flat area.

Remarks: This project will be accomplished during two tower shots in the Yucca area.

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Project Number: 1.1d

Title: Basic Air Blast Supporting Measurements

Sponsor: AFSWP

Performing Agency: Sandia Corporation

Project Officer: Dr. J. M. Harding, Civ.

Objective: To supply air drag measurements in support of Program 3.

To measure the direction of blast wave propagation by means of yaw gauges to aid in the study of the precursor phenomena.

To conduct feasibility studies on temperature, sound velocity, and density measuring systems.

Procedure: Gauges for measuring Q will be installed at various heights and at various distances from ground zero.

Gauges for measuring direction of particle velocity will be installed at 10 foot heights and at various distances from ground zero within the possible precursor region.

Gauge systems for the measurement of air temperature, sound velocity and air density will be installed at selected points in the Mach stem region and in a region where there is a possibility of obtaining a precursor.

Remarks: $Q = 1/2\ pv^2$
p = density of air
v = air partical velocity

This project will participate in KNOTHOLE 1 and 2.

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[redacted] [redacted]

Project Number: 1.2 Title: Air Blast Measurements

Sponsor: AFSWP Performing Agency: Naval Ordnance Laboratory

Project Officer: Dr. W. E. Morris, Civ.

Objective: To obtain free-air peak over-pressure vs distance.

To obtain quantitative and qualitative information concerning the precursor effect.

To obtain the path of the triple point.

To obtain effects of a smoke layer on the shock wave.

Procedure: The time of arrival of the shock front will be determined from a study of motion picture film taken of smoke trail grid established prior to zero time. Light from the intervening fire ball is reflected by the smoke trails. This reflected light is in turn refracted by the density gradient of the expanding shock front. The apparent breaks produced in the grid mark the arrival times of the shock front in the timed sequence of motion picture exposures. The peak over-pressures may be in turn deduced from these arrival times. In an attempt to extend the measurements closer to ground level the cameras will be mounted in a tower of a height sufficient to afford an unobstructed view of the ground in front of the smoke grid.

Remarks: This project will be accomplished on 1 airdrop and 1 tower shot in Yucca and KNOTHOLE 1 and 2 in Frenchman Flat.

[redacted] [redacted]

[redacted] [redacted]

Project Number: 1.3

Title: Free-Air Blast Pressure Measurements

Sponsor: U. S. Air Force

Performing Agency: Air Force Cambridge Research Center

Project Officer: Lt. Col. James O. Vann, USAF

Objective: To obtain pressure measurements above an air-burst atomic bomb. To measure blast pressure in the Mach stem and to determine the altitude of the upper end of the Mach stem (triple point) in at least one point.

Procedure: Deployment of fourteen (14) parachute-borne canisters will be accomplished from two (2) B-29 aircraft. A radiac telemetry system will record pressure-time data from the parachute-borne canisters. SCR-584 radar units will position B-29 aircraft in space and time during deployment of canisters.

A vertical array of seven (7) canisters will be deployed above ground zero, within a 30 degree angle from the vertical, at altitudes from approximately 3500 feet to 25,000 feet above ground level. A vertical array of seven canisters will also be deployed, approximately 12,500 feet horizontally from ground zero, at altitudes from approximately 2,000 feet to 15,000 feet above ground level.

Parachute-borne canister positions will be determined by the use of altimeter data and shock wave travel time and the use of the Multiple Object Tracking System is not required. However, if the MOTS system is used for another project, the canisters may be equipped with MOTS beacons for additional positional data.

Remarks: Reference is made to the report of Project 1.1 of Operation JANGLE and the report of Project 1.3 of Operation SNAPPER for background and theoretical work in making free-air blast pressure measurements of an atomic bomb detonation. Instrumentation and equipment used in Operation IVY will be utilized in KNOTHOLE. Status of instrumentation and equipment will depend on damage incurred during use on Operation IVY. This project will be accomplished on KNOTHOLE 1 and 2.

[redacted] [redacted]

Project Number: 1.4a [redacted] Title: Earth Pressure [redacted]

Sponsor: AFSWP Performing Agency: Sandia Corporation

Project Officer: Dr. J. M. Harding, Civ.

Objective: To determine the pressure-time vs depth in free earth relative to the incident air pressure at ground level. This is for a comparison with pressures to be measured on underground structures. Pressures at shallow depths will be measured for correlation with mine field studies.

Procedure: Earth pressure gauges will be buried at 1, 5, and 15 foot depths at various distances from ground zero to respond to vertical stresses. Gauge groups will be placed at 5 distances such that incident air pressures will vary from approximately 75 psi to 15 psi.

The output of all gauges will be recorded on equipment installed in the instrument shelter in the area.

Remarks: This project will be accomplished on KNOTHOLE 1 and 2.

[redacted]

[redacted]

Project Number: 1.4b Title: Earth Components [redacted]

Sponsor: AFSWP Performing Agency: Sandia Corporation

Project Officer: Dr. J. M. Harding, Civ.

Objective: This test will serve to indicate the magnitude and phase relationship of the horizontal components of stress with the vertical stress induced in the earth by an incident air-shock wave. It will also indicate the magnitude and phase relationships of the strains in the soil which correspond to the stresses and will furnish data from which the complete cynamic stress-strain induced by the air blast may be determined and correlated with the incident air-shock wave.

Procedure: Earth pressure gauges will be buried at 5 foot depth at one distance from ground zero for KNOTHOLE 1 and 2 to respond to five stress components including those in the vertical, radial and tangential directions, and at 45° between vertical and radial and radial and tangential directions. In addition earth strain gauges and earth acceleration gauges will be oriented to obtain 3 components of earth strain and earth acceleration.

Remarks: This project will be accomplished during KNOTHOLE 1 and 2 and the first tower shot in the Yucca area.

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PROGRAM 2

NUCLEAR MEASUREMENTS AND EFFECTS

LT COL E A MARTELL, USA

PROGRAM DIRECTOR

[redacted]

[redacted]

Project Number: 2.1

Title: Studies of Airborne Particulate Material

Sponsor: U. S. Army

Performing Agency: Chemical Corps

Project Officer: Colonel W. C. Hammond, Jr., USA

Objective: To determine the following characteristics of the particulate material in the cloud resulting from an air burst weapon:

(1) Particle size distribution.
(2) Distribution of activity with particle size.
(3) Fractionation of radio-nuclides with particle size.

To evaluate improved particulate sampling methods.

Procedure: Air sampling aircraft will be equipped with particulate sampling devices. It is planned to use the electrostatic precipitors and cascade impactors employed at Operation GREENHOUSE and JANGLE, improved to eliminate deficiencies pointed out by these operations.

Remarks: None

[redacted]

[redacted]

[redacted]

Project Number: 2.2a

Title: Measurement of Gamma Spectrum Fission Products

Sponsor: U. S. Army

Performing Agency: Signal Corps Engineering Laboratory

Project Officer: Mr. Robert C. Bass, Civ

Objective: To make measurement of the gamma energy spectrum of the residual contamination from an atomic detonation.

Measurements of this type are necessary to provide design criteria for radiac equipment.

Procedure: The scintillation spectrometer to be employed is of conventional design, utilizing the grey wedge photographic method of pulse height analysis. The pulses due to various energies of gamma radiation striking a scintillating phosphor are detected with a photomultiplier tube, amplified, and stretched to give a pulse of about 5 microseconds duration. These pulses are displayed on an oscilloscope and photographed through a linear density wedge. An iso-density line from the resulting photograph when corrected for crystal efficiency, etc., leads to a plot of the energy spectra of the radiation field over the present range of the detector. Two crystal detectors with overlapping ranges will be used.

The spectrometer will be used in radiation fields of up to 300 or 400 mr/hr.

The entire device is mounted in a suitable vehicle and moved into the radiation field where the measurements are made.

The analysis of the data is made quite straightforward by the overlap existing between the detectors. Considerable background work has been done on the problem of data analysis and the method adopted has been used in laboratory tests with excellent results. It is felt that results of the project could be presented very shortly after the tests, possibly at the test site.

Remarks: A scintillation spectrometer has previously been used for measurements of this type and although the results obtained are limited, the feasibility of the method has been proved. The present equipment has been designed to overcome several shortcomings of previous devices of this type. The equipment will be capable of making measurements continuously throughout the expected energy range without the difficulty of normalizing measurements made with detectors whose ranges do not overlap.

[redacted]

[redacted]

Project Number: 2.2b

Title: Residual Gamma Depth Dose Measurements in Unit - Density Material

[redacted]

Sponsor: U. S. Navy

Performing Agency: Naval Medical Research Institute

Project Officer: CDR F. W. Chambers Jr., USN

Objective: To evaluate the gamma energy distribution in areas of residual contaimination. To determine the effective energy of gamma radiation at points of low, intermediate and high field intensity and correlate this information with low intensity field spectrum measurements which are to be made by project 2.1a employing scintillation spectrometer techniques.

Procedure: Sets of unity density spheres of varying diameter, with gamma radiation dosimeters placed in a central cavity in each sphere, will be placed in areas of residual contamination by H + 1 hour following three tower bursts of moderately high yield. Plans are based on measurements at, at least three points in the range of gamma radiation intensity from 200 mr/hr to 50 r/hr. Recovery will follow exposure after a short time interval determined by dose-rate, exposure time and dosimeter response range.

Remarks: a. Pre-test laboratory calibration studies will be carried out to establish the degree to which the sphere technique will respond to moderate changes in the gamma energy distribution, particularly for changes in contribution to the total flux from the low energy region.

b. The problem of exposure of equipment in fields of gamma intensity in the range from 10 r/hr to 50 r/hr offers a radiological safety problem. Present project plans contemplate provision of lead shielding for truck driver and front mounted boom for equipment hauling.

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[redacted]

Project Number: 2.3 Title: Neutron Flux and Spectrum vs Range

Sponsor: U. S. Navy Performing Agency: Naval Research Laboratory

Project Officer: Mr. T. D. Hanscome, Civ.

Objective: To continue determination of the neutron flux as a function of range and the spectrum in the energy range from thermal to 1 - 3 MEV.

To obtain information for the development of satisfactory techniques for making accurate observations of the neutron flux and spectrum in the presence of an intense gamma ray source.

To support biological studies of neutron damage by providing the needed instruments.

To field Test new laboratory proven techniques or detectors.

Procedure: The use of neutron activation techniques to measure the neutron flux, choosing a distribution of thresholds to enable a measurement of spectrum distribution will be accomplished at several stations at various distances from ground zero. New techniques are being developed and it is proposed to field test those which indicate promise of success based on laboratory tests. Among the new techniques presently being considered is the use of nuclear track emulsion to measure the shape of the energy spectrum from 1 to 4 MEV.

Remarks: None

[redacted]

[redacted]

[redacted]

PROGRAM 3

STRUCTURES, MATERIEL AND EQUIPMENT

CDR C E LANGLOIS, USN

PROGRAM DIRECTOR

[redacted]

[redacted]

[redacted]

Project Number: 3.1 Title: Tests on the Loading of Building and Equipment Shapes

Sponsor: U. S. Air Force Performing Agency: Wright Air Development Center

Project Officer: 1st Lt. Bernard J. O'Brien, USAF

Objective: To investigate basic loading phenomena on parallelopipeds and other models. Correlate existing test data, future tests, shock tube, wind tunnels, high explosive experiments and full-scale tests like GREENHOUSE with this controlled field test.

Procedure: Seventeen (17) structures, as listed below, will be erected and instrumented.

Item	Size	Main Test Objective
3.1a	6x12x6	Effect of: Length, width, size, orientation, and elevation
3.1b	6x36x6	Effect of width
3.1c	6x6x6	Effect of width
3.1d	6x12x1.3	Effect of length
3.1e	18x36x18	Effect of size
3.1f	12x24x12	Effect of shock strength, size
3.1g	6x12x6	Effect of orientation (45°)
3.1h	6x12x6	Effect of orientation (22 1/2°)
3.1i	6x12x18	Effect of length
3.1 l*	6x12x1.3	Effect of shielding
3.1 m*	6x12x1.3	Effect of shielding
3.1 n*	6x12x1.3	Effect of shielding
3.1 o	6x12x6	Effect of elevation
3.1 p	6x12x6	Effect of elevation
3.1 q	6x10x11	Effect of reentrant corners
3.1 s	6x12x6	Regular reflection region and effect of shock strength
3.1 t	6x12x6	Regular reflection region

* These structures consist of two slabs 6 feet high, 12 feet wide, and 1.3 feet long. The distance between these slabs is varied in the three structures to obtain effect of shielding.

[redacted]

[redacted]

[redacted]

Project Number: 3.1 (con't)

Remarks: Many two-dimensional shock tube test results on parallelopipeds are available. Results on wind tunnel tests will be obtained before the spring tests start. Some of these structures suitably scaled down will be tested under high explosive blasts. Pretest analysis will be analytical and will take all available past, present and future experimental work into account. It is believed that the spring test in conjunction with analysis and other tests will furnish the most complete picture which can intelligently be expected of the loading on this most frequent type of building and equipment shapes. This project will be accomplished on KNOTHOLE 1 and 2, giving 2 pressure levels on all targets.

[redacted]

[redacted]

[redacted]

Project Number: 3.3 Title: Tests on Horizontal Cylindrical Shapes

Sponsor: U. S. Air Force Performing Agency: Wright Air Development Center

Project Officer: 1st Lt. Bernard J. O'Brien, USAF

Objective: 1. To obtain data on the loading transmitted to a non-deformable horizontal cylindrically shaped object supported just above the ground level in order to approximate the probable load from atomic blast on such target items as penstocks, conduits, horizontal tanks and to a limited degree on locomotives. It is anticipated that with such knowledge of loading the response of the target items noted can be obtained to a suitable extent by analytical calculations supported by laboratory tests.

2. As always a correlation of the prototype result with that of scaling laboratory or high-explosive tests will be made in the expectation that future fullscale tests on prototypes can be dispensed with.

Procedure: Four tubes of about 6 feet in diameter and one tube 1.5 feet in diameter both 20 feet long, which could be obtained by a combination of suitable steel pipes connected and capped would be anchored at each end to concrete foundations and oriented side-on to the blast in different pressure regions and distances from ground zero. The tubes as such will be of sufficient rigidity to withstand the pressure. Pressure measurements on the cylinder and end reactions will be measured. Free-air-pressure measurements in the vicinity will also be measured. The tests will be conducted in the Mach stem region. Sizes and distances from ground zero are indicated below.

Item	Size	Distance from G. Z.
3.3a	6' diameter, 20' long	4900 ft.
3.3b	18" diameter, 20' long	4900 ft.
3.3c	6' diameter, 20' long	6500 ft.
3.3d	6' diameter, 20' long	6500 ft.
3.3e	6' diameter, 20' long	6500 ft.

Instrumentation will consist of 6 pressure vs time gages on each cylinder, and special strain sensing units which will measure the end reactions on each support.

[redacted]

[redacted]

[redacted]

Project Number: 3.3 (con't)

Remarks: Some work, especially on half cylinders resting on the ground, has been done in the Princeton Shock Tube. Results will be used to further the objectives of pretest analysis. Further tests in shock tubes and possibly high-explosive tests on half and full cylinders, the latter in a position similar to that of the prototype test will be performed under loads emanating from high-explosive blasts. Water table experiments are also contemplated. This project will be accomplished on KNOTHOLE 1 and 2 with dual data being obtained.

[redacted]

[redacted]

[redacted]

Project Number: 3.4

Title: Test of Truss Systems Common to Open Frame Structures

Sponsor: U. S. Air Force

Performing Agency: Wright Air Development Center

Project Officer: 1st Lt. Bernard J. O'Brien, USAF

[redacted]

Objective: To obtain basic information on the loading transmitted to the principal parts of open frame structures by an atomic blast so that reasonably valid estimates of the over-all loading of such types of target structures can be made. From these data, it is anticipated that theoretical calculations will yield usable results of the response of open frame works carrying industrial equipment and being part of transportation systems.

It is desired to ascertain whether results of loading obtained in a proto-type test can be correlated with those obtained from scaled tests in wind tunnels and shock tubes. If scaling laws of this kind can be developed for the loading, data on similar shapes could be obtained by means of such laboratory techniques, rather than full-scale prototype tests.

Procedure:

1. The blast loading on one panel of a complete bridge system and the various parts of this system will be obtained by mounting these panels with orientation normal to the direction of the blast and by measuring the horizontal reactions and, if tilting is involved, the vertical reactions to the rigid body response of the panels. The systems to be tested are described as follows:

   a. One of a typical through truss bridge approximately 28 ft long to 45 ft in height, complete with deck designed for a single track railroad bridge.

   b. The top chord framing with a floor system.

   c. The bottom chord system with lateral bracing.

   d. One 20 ft length of wide flange stringer beam oriented with the web normal to the direction of the blast.

   e. Approximately 30 ft of single track plate girder bridge.

2. Horizontal and vertical reactions will be measured by

[redacted]

[redacted]

Project Number: 3.4 (con't)

[redacted]

dynamometers mounted on piers which are also carrying these structures. They will record load versus time. The total blast load on each system will be determined from the several reactions measured by the dynamometer. It is expected that from these loads a drag coefficient for the principal components in the completely assembled structures can be ascertained. Other instrumentation will be provided to measure free-air pressure versus time in the vicinity of the structures.

Remarks: Some knowledge of drag coefficients on trusses has been gathered from GREENHOUSE tests. It is desired to obtain other pretest data by experiments in wind tunnels to determine drag coefficients on structural elements and their relation to the total drag coefficients on a truss. Some tests on shock tubes and possibly high-explosive tests may be found to be desirable as soon as analytical pretest work has started. It is to be emphasized that this project is testing large bridges and large bridge components. This project will be accomplished on KNOTHOLE 1 and 2 giving 2 pressure levels on all targets.

[redacted]

[redacted]

[redacted]

Project Number: 3.5

Title: Tests of Wall and Roof Panels

Sponsor: U. S. Air Force

Performing Agency: Wright Air Development Center

[redacted]

Project Officer: 1st Lt. Bernard J. O'Brien, USAF

Objective: To determine the response of wall and roof panels subjected to the blast of an atomic bomb and to determine the load delivered to the supporting building frame by the panels. It is desired to obtain a correlation with laboratory tests completed or contemplated in order to obviate the necessity for other full-scale tests on such items.

Procedure: 1. Structures with test panels mounted thereon will be located at such distances from the expected point of detonation as will likely result in complete failure of the test specimens. Such failure will not be expected to be practically instantaneous but to permit observation of the loading and response through a distinct cycle of elastic, elasto-plastic and plastic resistance before collapse of the panels occurs. The structure as such holding the panels is not expected to go beyond the elastic range of resistance. Each structure consists of multiple cells which will support a wall or roof test panel either on all four or possibly on only two opposite sides.

2. Instrumentation will record:

a. The loading on the panel (pressure versus time).
b. The net forces delivered by the panels to the supporting frame.
c. The time sequence of response including cracking where observed.

3. The roof panels will be mounted on structures with front walls (as such not subject to testing) which will have a 20% opening in order to test the actual conditions under which most roofs will be subjected to pressures. Unlike the walls to be tested the roofs will therefore be under the influence of outside and inside pressures in the buildings.

4. If analytical investigations show the desirability of testing wall panels with openings these will be included.

[redacted]

[redacted]

Project Number: 3.5 (con't)

[redacted]

5. To conserve funds and avoid duplications, wall panels for the high and low pressure regions will be installed in two of four FCDA structures which are provided for project 3.29.

Remarks: Preliminary design of the structures has been accomplished and pretest methods for analysis of loading and response have been devised. In addition to GREENHOUSE data, data to be obtained in shock tube experiments and possibly in high explosive tests will be utilized before the prototype test gets underway. This project will be accomplished on KNOTHOLE 1.

[redacted]

Project Number: 3.6 [redacted] Tests of Railroad Equipment

Sponsor: U. S. Army

Performing Agency: Transportation Corps and Wright Air Development Center

Project Officer: Lt. Col. Donald G. Dow, TC USA

[redacted]

Objective: To provide information essential for the prediction of damage to enemy marshalling yards; and loaded and unloaded railroad rolling stock for purpose of target analysis, to determine the amount of damage (blast and thermal) in felation to distance from atomic detonation. To provide information on the effects of atomic blast and thermal effects upon our own marshalling yards and on rolling stock to include effort and time required to restore service and equipment; to determine dispersion criteria and calculated risk formulas and to test prediction tables and formulas.

Procedure: It is proposed to place the following equipment where indicated and with the listed instrumentation and photography:

Item No.	Item Name	Status	lbs/sq in
a	Box car, wood	Empty	2
b	Locomotive, DE 04-40	-	5
c	Box car, wood	Empty	5
d	Box car, wood	Loaded	5
e	Box car, o/s type (plywood)	Empty	5
f	Box car, wood	Empty	7
g	Box car, wood	Loaded	7
h	Box car, steel	Empty	7
i	Box car, wood	Empty	12
j	Box car, wood	Loaded	
k	Box car, o/s type (plywood)	Empty	12
l	Box car, wood	Empty	20
m	Box car, wood	Loaded	20
n	Tank car, riveted	Empty	20
o	Tank car, welded	Empty	20
p	Box car, wood	Loaded	25

[redacted]

[redacted]

[redacted]

Project Number: 3.6 (Con't)

Remarks: Some tests have been made under Air Force sponsorship in a 8"x8" shock tube to gather a general picture of the response of freight car models to various shock strengths. Multiple reflection of the shock wave between the bottom of the car and the surface of the track seems to be a very deciding factor. Analytical work of a preliminary nature has been completed on the overturning of cylindrical objects and parallelopipeds when they are enveloped by a shock wave. Static computations of the overturning moments of the various types of equipment to be exposed have been made, however the dynamic moments can not be so determined. By using the procedures outlined above, it is believed that this "norm" method will produce sufficient data to assess damage, determine optimum height and yield and provide dispersion criteria and information. The achievement of the objectives will be used as a basis for target evaluation, damage criteria and military planning.

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[redacted]

Project Number: 3.7

Title: Effectiveness of Blast Baffles at Shelter Entrances, Air Intakes and/or Outlets

Sponsor: U. S. Army

Performing Agency: Office, Chief of Engineers

Project Officer: Mr. William J. Matthews, Civ.

Objective: To determine the effectiveness of bends, traps, baffle, walls and other blast protection devices for shelter entrances, corridors, tunnels, ventilation ducts and air conditioning systems.

Procedure: The structures will consist of:

a. Semi-buried type shelters having covered passageways at one or both ends and equipped with appropriate air ducts with blast protection devices.

b. Groups of ducts with blast protection devices connected to plenum chambers in the ground. Suitable instrumentation will be provided.

Remarks: None

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SECRET

Project Number: 3.8

Title: Effects of Air Blast on Buried Structures

Sponsor: U. S. Army

Performing Agency: Office, Chief of Engineers

Project Officer: Mr. William J. Matthews, Civ.

Objective: To determine the interrelation between buried structures and ground shock induced by an air burst atomic weapon.

Procedure: Structures will be primarily box type, having a large number of simply supported beam strips in their roofs. The structures will be covered by different depths of earth and each structure will have beam strips of several degrees of flexibility to permit graded response. Results will be correlated with existing data. Project is of significant importance in determining criteria for designing military underground protective structures.

Remarks: None

[redacted]

[redacted] SECRET

Project Number: 3.9

Title: Design and Location of Field Fortifications

Sponsor: U. S. Army

Performing Agency: Engineering Research & Development Laboratory

Project Officer: Capt. Robert C. Nelson, CE

Objective: To determine the effects of atomic weapons on some typical emplacements of field fortifications of recommended design and to determine the suitability of specific modifications designed to reduce the effects of atomic weapons.

Procedure: One and two man foxholes and selected gun emplacements will be constructed by troops with organic tools and equipment, and reinforced, consistent with normal field capabilities, to minimize structural failure caused by air and ground shock. Design will be governed by a study of the failure of similar installations at the BUSTER/JANGLE Desert Rock exercise and available information on air and ground shock phenomena. Each emplacement will have film badges to monitor nuclear radiation effects and thermal paper to monitor thermal effects. However, the primary information will be secured by post test inspection to determine whether the emplacements are combat serviceable and whether the occupants might be casualties.

Remarks: None

SECRET [redacted]

[redacted] SECRET

Project Number: 3.11

Title: Protective Measures for Existing Construction; Light Steel Frame Structures

Sponsor: U. S. Navy

Performing Agency: Bureau of Yards and Docks

Project Officer: LTJG Phillip J. McEleney, USN

Objective: To determine the feasibility of strengthening a light steel frame building by increasing the moment resistance of beam - column or column-truss connections, adding to the anchorage connections, and strengthening attachments for roofing and siding. Similar structures were tested in Operation JANGLE. The strength of the unmodified prototype was thereby determined. This test will determine the resistance of the strengthened buildings.

Procedure: Two similar one-story buildings will be tested; one designed for 150 mph wind load and the other for a 70 mph wind load plus a 20 p.s.f. snow load on the roof. The first will be at range 12,500 feet and the second at 20,000 feet. There will be no instrumentation. The effects of both KNOTHOLE 1 and KNOTHOLE 2 will be determined by post-shot visual analysis.

Remarks: None

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Project Number: 3.12

Title: Protective Measures for Existing Construction, External Protective Measures

Sponsor: U. S. Navy

Performing Agency: Bureau of Yards and Docks

Project Officer: LTJG Phillip J. McEleney, USN

Objective: To determine the efficiency of simple means of external protection which can be applied to two common types of structures.

Procedure: One single-story brick, wall-bearing structure will be tested. This structure will simulate a masonry load-bearing wall protected by concrete panels similar to (but of improved design) those tested at GREENHOUSE. The structure will be completely enclosed with precast concrete panels to protect the sides and roof. No instrumentation will be provided. The effectiveness of the external protection will be determined by post-shot visual analysis.

Remarks: None

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[redacted]

Project Number: 3.13 Title: Precast Gable [redacted]

Sponsor: U. S. Navy Performing Agency: Bureau of Yards and Docks

Project Officer: LTJG Phillip J. McEleney, USN

Objective: To determine the ability of the Navy precast gable shelter to provide protection for personnel and critical materials.

Procedure: Two precast reinforced concrete gable bent structures, 22'x48', with vertical side walls will be tested. One will be protected with earth cover, the other will be unprotected. Instrumentation for earth and air pressure and displacement will be provided. The covered shelter will be placed at 2300 feet and the uncovered shelter at 4900 feet. Instrumentation will be operative on both KNOTHOLE 1 and KNOTHOLE 2 for the covered shelter, but for KNOTHOLE 1 only for the uncovered shelter.

Remarks: This type of structure is being considered for standardization as a personnel and critical material shelter and an evaluation in a field test is considered necessary. It was completely analyzed in Operation GREENHOUSE where several points of weakness were discovered. These have been corrected for the coming test.

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Project Number: 3.14 Title: Precast Warehouse

Sponsor: U. S. Navy Performing Agency: Bureau of Yards and Docks

Project Officer: LTJG Phillip J. McEleney, USN

Objective: To determine the blast resistance of a structure consisting of precast reinforced concrete panels over precast bents.

Procedure: A single story structure, instrumented for air pressure and displacement will be exposed at 6650 ft. range. The structure, similar to one tested at GREENHOUSE, has been modified to afford better response characteristics. This structure is typical of a large part of the Navy's current building program for shore stations. Instrumentation will be operative on the first KNOTHOLE shot only.

Remarks: None

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Project Number: 3.15

Title: Armco Steel Magazine

Sponsor: U. S. Navy

Performing Agency: Bureau of Yards and Docks

Project Officer: LTJG Phillip J. McEleney, USN

Objective: To compare the relative strengths of a semi-circular corrugated steel building to a similar precast structure being tested in Project 3.13.

Procedure: One 25' x 48' modified Armco ammunication hut will be located at 2300 feet from ground zero. The steel building will be covered and the end walls reinforced. Wing and blast walls will be arranged to allow entrance and exit at either end of the structure. A pre-shot analysis will be made. Instrumentation for earth and air pressure and displacement will be provided. Instruments will be operated on both planned KNOTHOLE shots.

Remarks: None

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Project Number: 3.16

Title: Test of Glazing and Window Construction

Sponsor: U. S. Navy

Performing Agency: Bureau of Yards and Docks

Project Officer: LTJG Phillip J. McEleney, USN

Objective: a. To determine the resistance of various types of glass and different types of wood, steel and aluminum window construction.

b. To determine the protection from flying glass afforded by the use of reinforced venetian blinds, curtains and wire mesh netting.

c. To determine the extent of the hazards and casualty producing capabilities of flying glass.

Procedure: Various types of windows and different methods of glazing will be exposed at suitable overpressure ranges in prefabricated wooden structures. The structures will be designed to resist the anticipated yields of the weapon, and the only failure expected will be the glazing, window construction and protective shielding mounted on the inside and outside of the window openings. Instrumentation will consist of high speed motion picture photography which will permit a study of the transient response of the glazing and possibly will furnish information regarding the effects of the negative phase of the blast wave. Three similar structures will be utilized at ranges of 20,000 feet, 12,500 feet and 7,600 feet, respectively.

Remarks: This test will supplement similar limited tests made in Operation GREENHOUSE.

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Project Number: 3.18 Title: Minefield Clearance

Sponsor: U. S. Army
U. S. Marine Corps

Performing Agency: Engineer Research & Development Laboratory

Project Officer: Capt. Robert C. Nelson, CE

Objective: To determine atomic effects on land mines, both U. S. and foreign and both anti-tank and anti-personnel, including variation of such effects as variation in depth of mine burial and minefield pattern (mine to mine spacing).

Procedure: An array of the various types of mines will be exposed, together with the Universal Indicator mines, the array to be adequately fenced off with barbed wire double apron and concertina fences to prevent accidental entry into the area, as well as to warn against intentional entry into the area.

Remarks: After post shot inspection, unexploded mines will be detonated in place. It is planned to use troops to construct and dismantle the fences and lay and clear the mines.

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Project Number: 3.19

Title: Effects of Atomic Explosion on Trees in Forest Stands

Sponsor: U. S. Army

Performing Agency: U. S. Department of Agriculture

Project Officer: Mr. A. A. Brown, Civ.
Dr. Keith Arnold, Civ. (Project Leader)

Objective: To determine effects of blast wave and associated winds on trees--in terms of tree breakage, branch breakage and defoliation--located in a forest area of such stand density that the shock front and its accompanying winds are influenced by the presence of the stand. To determine effects of forest cover on the shock wave and accompanying winds in terms of their penetration and attenuation in forest stands. To study effects of adjacent trees on drag forces of an individual tree crown. To compare effects of blast wave on individual trees in the open and trees in a stand. To establish criteria by which predictions of the above phenomena can be made for common forest cover types.

Procedure: A forest stand of 145 trees will be placed approximately 6500 feet from GZ where peak overpressures are about 6 psi. At each of 8 stations located at various intervals from 1500 to 8,000 feet, inclusive, three isolated threes will be placed. Two lollipops (weighted disks on beams) will be placed at each of 4 stations, and 4 lollipops will be placed within the stand.

Strain meters will be placed on one tree inside and on two trees outside the stand to measure strain-time history at base of crown and at stump height one foot above ground. Acceleration at the center of pressure will be measured on one tree outside the stand and one tree inside the stand. Maximum strain along the length of the stem will be measured by scratch gages on 4 trees inside the stand and on 4 isolated trees. Maximum deflection will be measured on every tree by snubbers. Twenty-seven air pressure and 4 organic pressure measurements will also be made within the stand. Motion and breakage will be recorded by moving pictures.

Remarks: Preliminary analysis of damage to trees by shock wind indicated that at sea level, conifers 24 inch DBH with 50% crown and a natural period of 2.5 sec would be expected to break at an overpressure of 7.5 psi in the Mach stem region. Subsequent work showed that drag force from blast winds could be correlated with dry weight of crown, and that ponderosa

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Project Number: 3.19 (con't)

pine stems subjected to static loading fail when maximum stress is of the order of 3,00 lb/sq inch. The above studies provided the basis for design of Project 3.3, Operation SNAPPER, which sought to predict blast damage to isolated coniferous trees from atomic explosions. Project 3.3 showed that peak kinetic energy is a more accurate parameter than peak overpressure for predicting blast damage to trees and other structures which have comparatively long periods and are susceptible to damage by aerodynamic drag. The upper limit of shock peak kinetic energy for breakage of isolated confiers is approximately 0.5 psi with 1 second positive phase duration. This value of kinetic energy corresponds to a sea level overpressure of 4.5 psi for Mach reflection.

Stated objectives should be achieved at this test because no analytical or scaled model solution appears practicable. The military has asked the Forest Service for early achievement of these objectives for offensive and defensive planning purposes since many military operations are conducted in forest areas.

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Project Number: 3.20

Title: Vulnerability of Typical Tactical Communications Systems to Atomic Attack

Sponsor: U. S. Army

Performing Agency: Signal Corps Engineering Laboratory

Project Officer: Mr. Jacob Eggert, Civ.

Objective: To determine the blast and thermal effects of an atomic bomb on typical tactical communication systems.

Procedure: Several dispositions of typical communications nets will be exposed at various distances from ground zero. One system will be standard, others will employ various degrees of protective countermeasures - burying, alternate lines, etc. An analysis of the effects of the weapons on these nets will include the work necessary and time to re-establish them in working order.

Remarks: None

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Project Number: 3.21

Title: Statistical Determination of Damage Criteria for Critical Items of Military Equipment and Supplies

Sponsor: U. S. Army

Performing Agency: Ballistics Research Laboratory

Project Officer: Mr. Edward J. Bryant, Civ.

Objective: To obtain statistical data on damage to critical items of military equipment.

To give immediate correlation between observed damage to actual materiel and that predicted from information gained from previous tests on military equipment exposed to nuclear blasts and to obtain information to check prediction methods devised by Armour Research Foundation of rotational and translational motion of military equipment.

Procedure: Twenty-seven 2-1/2 ton trucks, twenty-seven 1/4 ton trucks, and two 90mm AA will be exposed on the first KNOTHOLE shot. Measurements will be made as follows:

a. Pressure-Time of air blast.
b. Technical Photography
   a. Still - before and after test.
   b. Motion pictures - during occurence of transient blast phenomena.
c. Accelerometers placed on items to determine rotational and translational motion.
d. Pressure-time gauges placed on items to determine pressure loading forces on item.
e. Stakes driven in ground to measure displacement of item.

Twenty-seven 105 mm howitzers and nine medium tanks will be exposed on the second KNOTHOLE shot. Measurements will be made as follows:

a. Pressure-time of air blast.
b. Technical Photography.
   a. Still pictures - before and after tests.
   b. Motion pictures - during occurence of transient phenomena.
c. Stakes driven in ground to measure displacement of item.

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Project Number: 3.21 (con't)

Remarks: A survey of all data previously obtained has been conducted. The upper and lower limits have been established for various degrees of damage on several of the items of military equipment. A design of the statistical test is in process for distribution of items within these limits. Calculations are being made for rotational and translation motions of the item expected on Operation KNOTHOLE using Armour Research Foundation prediction method.

Test will give a basis for predicting damage on a statistical basis and confirm previous data.

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Project Number: 3.22

Title: Effects on Engineer Bridging Equipment

Sponsor: U. S. Army

Performing Agency: Engineer Research & Development Laboratory

Project Officer: Capt. Robert C. Nelson, CE

Objective: To determine atomic effects on standard engineer bridging material.

Procedure: Two bridges, each 100 feet long, will be erected normal to the blast and at pre-determined distances from ground zero. Suitable instrumentation will be provided so that results obtained may be correlated with extensive laboratory studies which have been conducted. Each bridge will be set on piers constructed of Bailey Bridge panels. The bridges will be allowed to move laterally under the effect of the blast and shock against a known restraint. The accelerations will be measured electronically, and movement will be photographed with motion picture cameras.

Remarks: It is planned that troop labor will be used to erect and salvage the Bailey Bridges.

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Project Number: 3.24

Title: Effects of an Air Burst Atomic Explosion on LVT's

Sponsor: U. S. Navy

Performing Agency: Naval ~~Research and Development~~ Radiological Defense Laboratory

Project Officer: Lt. Col. Merlin R. Olson, USMC

Objectives: To determine blast damage to LVT's positioned at various distances from ground zero.

To determine qualitatively, the degree of shielding afforded by LVT's from an atomic air burst.

To make an operational analysis of all observable damage.

Procedure: It is planned to utilize six of the newly developed amphibious personnel landing craft, the LVT-5, for the project. These vehicles will be positioned at various distances from ground zero to determine the zones of "severe", "moderate", and "light" blast damage and the overpressure required for such damage. The orientation of the vehicles at the predetermined distances will be varied to obtain maximum damage criteria data. The positions and condition of the vehicles will be photographically documented prior to, and following, the blast. Photos will be taken from substantially identical locations each time, plus such other photographs as required to document existing damage. A detailed operational inspection and analysis of test vehicles will be conducted at the test site following the atomic bomb detonation. In the matter of measuring shielding afforded from nuclear radiations, it is planned to place film badges in and outside of all vehicles. The film badges placed inside the vehicles will be located in positions corresponding to the normal areas occupied by personnel. In addition, film badges will be attached to brackets, so that the readings obtained will be such as to approximate the location of the center of an individuals body. Following development of film badges, it is expected that a general radiation reduction factor for initial radiation can be established by comparing the readings of the film badges exposed outside of the vehicles against those inside. It is further contemplated that other dosimeter types will be utilized to the fullest extent possible, such as the crystal dosimeter- DT-60.

Remarks: This project was requested by BuShips, based on a stated requirement from the U. S. Marine Corps. The only data available on effects

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Project Number: 3.24 (con't)

of an atomic bomb detonation on LVT's resulted from placement of two LVT(#)C(M) on Exercise Desert Rock IV-Marine Corps, for the express purpose of demonstrating blast effects to participating troops. General blast, thermal and nuclear radiation data are available from publications such as "Capabilities of Atomic Weapons", but data are not available regarding damage criteria for LVT's, i.e., degree or extent of damage vs overpressures, degree of shielding afforded by vehicle vs nuclear radiations, etc. The data obtained by achievement of the stated objectives will serve a primary purpose of providing information for revision of amphibious doctrine.

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Project Number: 3.26.1

Title: Effects on POL Installations-Drum and Can Storage

Sponsor: U. S. Air Force

Performing Agency: Air Materiel Command Office, Chief of Engineers

Project Officer: 1st Lt. Bernard J. O'Brien, USAF

Objective: To obtain data on vulnerability of oil and gasoline in drum storage as found in military fuel drums and vulnerability of liquid fuel products in vertical storage tanks. Specifically, it is planned to determine the destructive agencies, degrees of damage, rupture of drums, spillage, vulnerability to fire at varying distances and the maximum range at which tanks will be ruptured or otherwise damaged.

Procedure: 1. Approximately 30 diesel oil drums of 55-gal. capacity each will be stacked in piles. There will be 16 piles in all. These piles will be oriented normal and parallel to the blast wave at each of seven locations at various ranges from the expected ground zero. If calculations show that interference of flying drums with test results is not expected these seven locations will be on a common radial line. These tests will be run in cooperation with the Quartermaster Corps of the Army who will test a number of 55-gal drums filled with motor gasoline at various distances from expected ground zero. Some of these latter tanks will be protected by revetments; some will be lashed together; and all will be oriented end-on to the blast.

2. Twenty additional single drums will be provided with a frangible element which is expected to rupture at the first impact of the shock wave and which will allow us to study the likelihood of primary and secondary fires resulting from spillage. There will be four frangible drums at each of five stations, two containing diesel oil and two containing aviation gasoline.

3. All drums will be stacked in accordance with Air Force practice and marked by an identifying designation on the lee side of each drum.

4. Instruments will be provided to measure temperature-time and pressure-time relationships at suitable check points near some of the 10 storage dumps. A pictorial record of all incidents will be made by motion picture photography.

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Project Number: 3.26.1 (con't)

5. Another test involving oil and gasoline storage will be made by placing four vertical s teel t anks on a common radial line at varying distances from the expected ground zero. The tanks will be selected from commercially available tanks of a size approximately 15 feet in diameter and 10 feet high, and will be filled with water for test purposes. Tanks will be of welded steel construction. In addition, two Corps of Engineer bolted steel tanks of approximately the same size will be located at points yet to be determined on the same radial line as above.

6. Instrumentation will be provided to obtain the free-pressure versus time-curves in each location. It is intended also to instrument for actual loading on one of the four welded steel tanks. A pictorial record of motion picture photography shall be provided to give over-all response, particularly in the closest locations where considerable effects are likely.

Remarks: 1. Extensive investigations have been completed analytically and by shock tube experiments on the response of stacks of cylindrical drums to shock. A report on these investigations will be forthcoming soon. Further tests involving vertical cylinders in shock tubes and analysis of loading and response under conditions of various percentages of innage would be performed before the atomic test.

2. Some work on ignition has been initiated. Derivation of scaling laws is one object of the test. If pretest calculations indicate the advisability and feasibility some tests will be performed with high explosives and possibly in wind tunnels.

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Project Number: 3.26.2

Title: Effects on POL Installations, Systems and Hazard from [redacted] Spillage

Sponsor: U. S. Army

Performing Agency: Quartermaster Corps

Project Officer: Mr. H. A. Stiles, Civ.

Objective: The objective of this project is to determine the susceptibility of normal, operating, field petroleum dumps to the combined blast and thermal effect of an atomic weapon and to evaluate protective measures.

Procedure: It is proposed to expose identical representative displays of QM tanks, drums, and a single 900 gal. collapsible container and cans at each of 4 stations (48,24, 12, and 6 cal/cm^2 of thermal energy) to an airburst where heat and blast will be most effective. The stacks of drums and cans are designed to represent the best practice as prescribed in manuals and variations as are common in field installations. Gasoline will be used to fill all containers, except the 900 gallon collapsible container.

A can cleaning plant, including a 50 gpm pump, will be used at each station to circulate gasoline through the can cleaner and 5 gallon, cans, thus providing a continuous source of highly combustible gasoline fumes in the atomosphere.

Evaluation of the extent and cause of damage will be largely by visual examination of the installation after exposure. Moving pictures at 32 frames per second will be taken. Still photographs, before and after, will also be taken for reference purposes.

Remarks: The Quartermaster Corps of the Army has the responsibility for the field storage and issue of petroleum products. While many items were exposed to atomic weapons effects at Bikini, no attempt was made to simulate field installations of this type. Also, much has been learned both about effects of atomic weapons and effects testing since that date. A POL supply point represents the most hazardous supply operation, and would probably be a profitable target for atomic weapons. Laboratory tests to determine the effects of an atomic exposure are not practical. Data is available, or will be obtained, regarding the strength characteristics of the individual containers. Additional laboratory work may be required after the test if it is determined that any of the items included in the test should be redesigned.

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Project Number: 3.26.3. Title: Effects on POL Installations-Bulk Storage

Sponsor: U. S. Marine Corps Performing Agency: Marine Corps Equipment Board

Project Officer: Lt. Col. H. W. Sharpenberg, USMC

Objective: To determine the effects of an atomic explosion on a Marine Corps amphibious assault fuel system. Resistance of materials and equipment to thermal and blast damage is desired. Present concepts of equipment dispersion, revetments, camouflage covers, etc. is desired. Results of tests to be employed in effecting design of procurement system.

Procedure: It is planned to utilize five (5) test sites. The first site will be placed within the fringe area where damage may be expected. Laboratory tests indicate this to be in the 27-29 cal/cm^2 zone. The equipment and method of installations at all tests sites will be identical and will consist of three (3) 10,000 gallon collapsible tanks, of which two (2) will be filled with motor gasoline; the third empty.

Of the two (2) filled tanks one will be provided with draped camouflage covering. The three tanks will be laid on 100 foot centers with their longitudinal axis parallel to the blast. The two (2) filled tanks are connected at 100 foot distance to a gasoline pump; all the units will contain gasoline. The fuel will be pumped by the fuel system equipment into the tank form.

Remarks: None

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Project Number: 3.27

Title: Effect of Atomic Weapons on Field Medical Installations

Sponsor: U. S. Army

Performing Agency: Medical Field Service School

Project Officer: Lt. Col. Edwin S. Chapman, MC, USA

Objective: To determine the effects of an atomic explosion upon Army Medical Service equipment and installations at various distances from ground zero.

Procedure: It is planned to place composite installations containing equipment at various distances from ground zero (500 - 900 - 1700 - 3,000 yds.) in dug-in positions and on the surface. This equipment, etc, to be placed in tentage appropriate to medical installations of the field army with dummies to represent personnel of the units as well as patients under treatment within the installations. Determination of radiation, thermal, and blast measurements to be made at each location. Photographs (motion pictures) to be made within surgical, X-ray, pharmacy, ward, and laboratory tents at selected locations to determine the effects of items of equipment contained therein acting as a source of further injury to patients and personnel in becoming secondary missiles as a result of the explosion. Subsequent to explosion, evaluation of the suitability of equipment for further use by appropriate personnel. Before and after still photographs to be taken of installations and equipment.

Remarks: This project will provide planning data for the Army Medical Service for the determination of the following:

a. Materiel and equipment requirements in the theatre of operations.
b. The ability of various types of field medical installations to withstand serious structural damage.
c. The resistance of items, units, and susceptible assemblies to blast and thermal damage.
d. Overall ability of medical units to continue to operate effectively.
e. The validity of current doctrines and procedures.
f. The advisibility of modifying present doctrine with regard to digging-in medical installations.

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Project Number: 3.28.1 Title: Structures Instrumentation

Sponsor: U. S. Army Performing Agency: Ballistic Research Laboratory

Project Officer: Mr. Julius J. Meszaros, Civ.

Objective: To provide, install and operate all instrumentation of test structures in Program 3. To reduce all field data to the best form for further use by the structures research groups. To act as technical expert on instrumentation and as consultant on air blast.

Procedure: BRL will provide 475 channels of instrumentation for Program 3 to measure strain, air blast, earth pressure, panel-break, temperature, voltage, current, acceleration and displacement.

BRL will use the Webster-Chicago recording system previously used by Sandia Corporation. This equipment is being modified to correct the various faults previously observed and insure better operation.

Remarks: None

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Project Number: 3.28.2 Title: Structures Instrumentation

Sponsor: U. S. Navy Performing Agency: Naval Ordnance Laboratory

Project Officer: Dr. W. E. Morris, Civ.

Objective: Same as 3.28.1

Procedure: NOL will provide 145 channels of instrumentation for pressure-time measurements on or near structures of Program 3. Also, NOL will make diffraction studies in the vicinity of structure 3.1(f), a rigid parallelopiped 24' wide, 12' deep and 12' high.

Remarks: None

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Project Number: 3.28.3 Title: Structures Instrumentation

Sponsor: AFSWP Performing Agency: Stanford Research Institute

Project Officer: L. M. Swift, Civ.

Objective: To determine pressure-time relationships at points on a number of non-responding targets for correlation with similar and other data obtained by other agencies.

Procedure: Pressure-time relationships will be recorded and measured at points on targets as directed by the DWET and the planning and analytical agency to the extent of approximately 70 channels of information.

Variable-reluctance gauges will be used as the primary transducers. Therminal equipment and recorders will be located centrally at each area. Recording will be by oscillographs on photo-sensitive recording paper.

Remarks: This agency will obtain data which will be combined with those obtained by other agencies for determination of target loading

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Project Number: 3.29

Title: Test of Four FCDA Curtain-Wall and Partition Structures

Sponsor: Federal Civil Defense Administration

Performing Agency: FCDA

Project Officer: Mr. Benjamin C. Taylor, Civ.

Objective: To determine the resistance of various types of structures and components thereof.

Procedure: Four structures will be exposed, two each at 4200 feet and 6500 feet respectively. One structure at each range will be modified to fit test panels to complete the objectives of project 3.5. Each structure and test panels will be appropriately instrumented.

Remarks: None

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PROGRAM 4

BIO-MEDICAL EFFECTS

LT COL E PINSON, USAF

PROGRAM DIRECTOR

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Project Number: 4.1

Title: Evaluation of the Hazard of Flying Through the Atomic Cloud

Sponsor: U. S. Air Force

Performing Agency: Air Force Cambridge Research Center

Project Officer: Capt. Paul M. Crumley, USAF

Objective: To evaluate the hazard from flying through an atomic cloud. Measurement of gamma radiation as well as inhalation hazards will be made using QF-80 drones. Gamma measurements using parachute-borne canisters hitting the cloud at 25,000 and 38,000 feet are desired as a function of time after burst and position relative to the cloud.

Procedure: Parachute-borne canisters will be dropped from aircraft so that five canisters will hit the cloud mushroom at 25,000 feet and 5 canisters will hit the cloud mushroom at stabilization altitude. The gamma measurements will be telemetered to ground receivers. Two QF-80 drones equipped with animals and self-recording gamma measuring instruments will be flown through the cloud. One drone will penetrate at 30,000 feet and the other at 35,000 feet.

Remarks: None

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Project Number: 4.2 [redacted] Title: Air Blast Injuries

Sponsor: U. S. Navy

Performing Agency: Naval Medical Research Institute

Project Officer: Capt. R. H. Draeger, MC, USN

Objective: To determine the range of direct atomic bomb air blast injuries in several animals (mice, rats, rabbits, and dogs.).

Procedure: It is planned to place eight (8) exposure units containing animals at each of seven (7) stations within range of 20 to 50 psi. A total of 1,000 swiss mice, 500 rats, 200 rabbits, and 60 dogs will be used. About 12 hours following exposure to air blast overpressure these animals will be autopsied in order to evaluate injuries. It is desired to place about 6 exposure units within these ranges at Upshot 3 as a preliminary study.

Remarks: Operation GREENHOUSE animal exposure containers were modified and tested at TUMBLER/SNAPPER. These containers were found to be suitable for the exposure of animals to the direct effects of air blast overpressure and will be used during UPSHOT/KNOTHOLE for this purpose.

Prototype instruments for the measurements of blast pressures and duration of pressure waves were developed and tested at TUMBLER/SNAPPER. These instruments are now being redesigned for better performance.

Preliminary tests using a modified shock tube are being conducted with a view to determining the range of pressure to be covered in these field test studies.

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Project Number: 4.5 Title: Flash Blindness

Sponsor: U. S. Air Force Performing Agency: School of Aviation Medicine

Project Officer: Col. Victor A. Byrnes, USAF(MC)

Objective: To study effect of high intensity illumination in respect to retinal burns and visual field changes.

Procedure: Fundus and histological studies will be made on rabbits at appropriate time intervals after exposure to flash of atomic detonation. These animals will be located at pre-determined distances from target.

Human subjects, protected by filters will be exposed to flash by shutters mounted in specially designed trailers situated at a predetermined distance from target. After exposure subjects will be tested to determine depth and duration of scotomata and effects on dark adaptation. Follow-up exams will be made at regular intervals.

The ability of flying personnel to read instrument panels after high intensity illumination will be evaluated.

Remarks: Depth and duration of scotomata were studied during Operations BUSTER/JANGLE and TUMBLER/SNAPPER. The effect of high intensity illumination on dark adaptation and protection provided by various types of filters was studied also at these operations.

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PROGRAM 5

DRONE PROGRAM

CDR K H STEFAN, USN

PROGRAM DIRECTOR

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Project Number: 5.1 Title: Naval Aircraft Structures

Sponsor: U. S. Navy Performing Agency: Bureau of Aeronautics

Project Officer: CDR Karl H. Stefan, USN

Objective: To obtain information and test data which can be utilized to verify or redefine the safe operational limits of the model AD-2 aircraft as a weapons carrier. In addition, it is intended to perform a dynamic analyses as effects of gust loading on the aircraft and to investigate the effects of dynamic over-stressing on the structure. From this work, improved methods for analytically determining the effects of atomic explosions on aircraft will be developed.

Procedure: A drone model AD-2 aircraft equipped with both telemetering and direct-recording instruments for the measurement of structural load, accelerations, temperatures and other parameters associated with the determination of structural response will be flown under drone procedure to a predetermined point in space representative of delivery of an atomic weapon by a Model AD-4 airplane. Radar tracking equipment will be used to track and direct the flight of the drone aircraft. Manned fighter aircraft will stand by to shoot down drone in case of malfunction.

Remarks: Preliminary studies and calculations have been made to investigate or determine what effects atomic explosions had upon aircraft in flight. Such work has been performed with particular reference to the effects of gamma radiation, thermal radiation, free-stream overpressure, and gust loading on the Model AD-2 type aircraft.

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Project Number: 5.2

Title: Blast, Thermal and Gust Effects on Aircraft in Flight

Sponsor: U. S. Air Force

Performing Agency: Wright Air Development Center

Objective: To measure the structural response characteristics of a medium bomber when exposed to the blast, thermal, and gust effects of a 30KT atomic bomb at near-critical ranges, i.e., at an overpressure range of 1 psi. To determine minimum operational parameters for aircraft of this type, for delivery of atomic weapons. To measure, if consistent with the primary objective, the response of aircraft to the reflected shock, under conditions of structural resonance. To obtain data on wing and stabilizer stresses, aircraft accelerations, and skin temperatures.

Procedure: One (1) B-50D airplane is being instrumented with strain gages, accelerometers, thermocouples, and pressure gages whose outputs will be recorded by two (2) 18-channel oscillographs plus two partially instrumented B-50D aircraft furnished by SAC. After calibration, practice missions will be flown, followed by participation in Operation KNOTHOLE Shot #1. It is planned that participation shall be accomplished under the following flight plan; departure from Kirtland AFB scheduled so as to arrive over the target area at the proper time, with adequate margins of time for dry runs, and for proper positioning and altitude at shot time, followed by return to Kirtland AFB.

Remarks: Previous measurements of structural loads on aircraft in flight exposed to the atomic burst of Operations CROSSROADS, SANDSTONE, and GREENHOUSE have furnished information on the general nature of the structural response. Theoretical analysis of this information has led to an understanding of the basic principle involved, permitting general calculation of blast loads at conservative distances from atomic bursts. However, response data in the region approaching minor damage is meager or non-existent, particularly for high-performance medium bombers. This response data is needed now so that safe minimum procedures may be established for aircraft delivering atomic weapons.

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PROGRAM 6

TEST OF SERVICE EQUIPMENT AND OPERATIONS

LT COL D.I. PRICKETT, USAF

PROGRAM DIRECTOR

[redacted]

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[redacted] SECRET

Project Number: 6.2

Title: Tests of Radar Techniques for Accomplishing Indirect Bomb Damage Assessment

Sponsor: USAF

Performing Agency: Wright Air Development Center

Project Officer: Mr. Frank E. James, Civ.

Objective: To obtain scientific and experimental radar to assist in the development of an IBDA system.

Procedure: Task I proposes a ground radar installation to record the radar return phenomena from time-zero through some 30 seconds. Additional information regarding refraction of radar signals around the fire-ball is to be obtained.

Task II proposes the testing of a beacon technique in determining ground zero combined with obtaining continuous radar data from time-zero from airborne radar.

Task III proposes investigation of the "fast scan" technique combined with Ku-band radar to determine the improvement in IBDA which may be expected by the employment of such a technique.

Task IV proposes investigation of the AMTI principle as applied to detection of atomic detonations. It is believed that AMTI PPI photographs combined with standard radar PPI photographs may give better accuracies in the determination of the IBDA parameters.

Remarks: Radar results obtained on Operations CROSSROADS, SANDSTONE, GREENHOUSE, BUSTER/JANGLE, and TUMBLER/SNAPPER indicate a radar return can be obtained from an atomic explosion which can be used in determining ground zero, and will indicate gross errors in height of burst and yield. The cause of the radar return and improved methods of detecting and recording the return must be investigated to provide the Armed Forces with an all weather IBDA system.

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Project Number: 6.3 Title: Field Test of IBDA

Sponsor: USAF Performing Agency: Strategic Air Command

Project Officer: Capt. R. E. J. Scott, USAF

Objective: To determine by tests under field conditions current IBDA capabilities.

Procedure: Strategic Air Command aircraft with standard combat equipment will fly in positions with respect to the bomb drop aircraft which simulate probable strike and support aircraft formations over a target. These aircraft will take data essential for the determination of the three IBDA parameters, yield, height of burst, and ground zero. In addition to the bomb carrier, a minimum of ten aircraft to form the combat configuration are required for the project. Each of these aircraft will be equipped with the latest available IBDA systems.

Strategic Air Command aircraft and crews will be utilized for this project. Upon completion of the mission, at the Nevada Proving Ground, these aircraft will return immediately to home bases where the data collected will be processed and analyzed, using the same procedures and time schedule as prescribed in the SAC Reporting Guide and other standing operating instructions.

Upon completion of the tests, the strike reports of the damage estimated by IBDA means will be compared with the actual damage determined by detailed assessment of the target structures.

Remarks: None

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Project Number: 6.4

Title: Evaluation of the Chemical Dosimeter

Sponsor: U. S. Army

Performing Agency: Chemical Corps Chemical and Radiological Laboratory

Project Officer:

Objective: To assess the operational characteristics of the E-1 Tactical Dosimeter and several administrative instruments under development as personnel dosimeters for measuring the gamma radiation received from an atom bomb detonation. As a secondary objective, final engineering tests will be conducted on the E-1 Tactical Dosimeter as part of the work necessary to making this item an interim standard.

Procedure: The Chemical Corps has under development the Tactical Dosimeter E-1 (Taplin Choroform-water and dye system) as a result of continuing evaluation of chemical dosimeters at Operations GREENHOUSE, JANGLE and TUMBLER/SNAPPER. Continued evaluation must be carried out as new developments occur, or as improvements are made to overcome deficiencies. With regard to an administrative dosimeter, the Chemical Corps has for developmental consideration the very promising Farrington-Daniels Thermoluminescent lithium fluoride crystal system which has yet to be officially tested under bomb conditions. Evaluation tests are necessary if this development work is to continue. Other promising dosimeter systems available by the test date will likewise be evaluated with regard to initial gamma radiation from the bomb.

It is proposed that chemical dosimeters be placed within the region of initial gamma radiation from the atomic bomb detonation.

Remarks: The Tactical Dosimeter E-1 has a dose rate dependence. It is imperative to conduct studies at fast dose rates (bomb rates) in order to determine the efficiency of additives to the systems which would correct for this inherent rate factor.

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Project Number: 6.7

Title: Electromagnetic Radiation over the Radio Spectrum

Sponsor: U. S. Army

Performing Agency: Signal Corps Engineering Laboratory

Project Officer: 1st Lt. Walter T. Kerttula, USA

Objective: To measure the pulse shape, polarization, amplitude and duration of the radio frequency signals due to nuclear detonations. To deduce from these measurements the power density spectrum of the electromagnetic wave at the point of measurement and correlate this with the bomb yield.

Procedure: The measurements are to be taken at a single station located at 10 to 15 miles from GZ. At this distance, the induction field for all frequencies above about 200 kc will be negligible. Additional distance, while very slowly reducing the frequency at which the induction field becomes negligible, would add to propagation difficulties. The final choice of antennas has not yet been made. They will be relatively small and of simple design in order to meet the requirements that they be independent of ground constants and that the determination of the field strength from measured antenna output can be carried out in a reasonably simple and accurate manner. In the event that an adequate mathematical analysis is not evolved in time to be used, it will be necessary to calibrate the equipment directly. For field strength measurements the antenna will drive three oscilloscopes with triggered sweeps, one for short time resolutions, of the order of 100 microseconds, one for long times, in the order of 0.1 seconds, and one modified for a non-linear sweep, thus insuring that at least one record of the full duration of the disturbance will be obtained. For polarization measurements one oscilloscope will be employed using the signals from crossed antennas as vertical and horizontal sweeps, thus graphing the vertical versus horizontal field components. This may be further implemented by a pair of oscilloscopes to record each component on a time base. The signals will be recorded on still cameras. If calibration procedures are deemed necessary, standard commercial field strength meters and field generators will be added. The frequency range to be covered will be that of the Tektronix 513D oscilloscopes (DC to about 18mc). Suitable timing equipment will be provided for locating zero time on the records.

Remarks: Previous projects have indicated the presence of radio frequency signals associated with a nuclear explosion. The results of Project 8.5 (TUMBLER/SNAPPER) indicate that the energy in these signals is concentrated

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Project Number: 6.7 (con't.)

in the very low frequency region, with very little energy above 10 mc. Theoretical calculations based on a simplified model tend to substantiate this conclusion. All previous measurements have been qualitative and of such a nature as to make a determination of the true pulse shape impossible. No data has been obtained on polarization. The measurements to be made are intended to provide quantitative data for the achievement of the stated objective for comparison with the above-mentioned simplified theory and possibly for use as a basis for further theoretical investigation.

[redacted]

Project Number: 6.8 Title: Evaluation of Radiac Instrumentation, Equipment and Operational Techniques

Sponsor: U. S. Army and U. S. Navy Performing Agency: Signal Corps Engineering Lab and Bureau of Ships

Project Officer: Mr. Joseph M. Johnston, Civ.

Objective: To evaluate under actual field conditions all existing radiac rate meters and dosimeters that have been constructed for military use. This will include the list of all new instruments of both Army and Navy. Decisions reached by this evaluation will substantially effect the future development of field instruments.

Procedure: Development continues to produce light-weight simple, dependable, military rate and dose meters that will satisfy the needs of all using forces. Tests conducted during 1951 showed the practicability of smaller gear and pointed the way toward better mechanical design and different form factors. Rate meters being prepared for current tests will incorporate changes in design as a result of data collected from past tests. These tests will incorporate:

1. Organized field trips into contaminated areas by personnel carrying rate equipment.
2. Strategic placing of dose meters at various distances from ground zero to determine effects of heat, rate, and other phenomenon.
3. Issuance of rate meters to radiological safety personnel for comparison with present production equipment.
4. Issuance of rate meters to experienced test personnel on an informal basis with a questionnaire sheet soliciting technical comments.

Remarks: None

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[redacted] [redacted]

Project Number: 6.9 Title: Evaluation of Airborne Radiac Equipment

Sponsor: U. S. Navy Performing Agency: Bureau of Aeronautics

Project Officer: CDR John H. Terry, USN

Objective: To evaluate airborne radiac equipment including aerial ground survey equipment, automatic recording dosimeters, droppable telemetering and flare units. Equipment is to be evaluated to determine errors and corrections in data taken at altitude relative to data taken at ground level.

Procedure: A P2V-2 airplane, presumably based at KAFB, will proceed to the proving ground on shot day. It will orbit prior to the shot and when cleared to enter the shot area, will conduct ground survey from the air, making repeated runs over the contaminated area to obtain data. If permission granted, will drop gamma dosimeters telemetering units into the area and monitor these units from the plane. If permission granted, will also drop gamma intensity flares which in a radiation field will ignite a colored flare whose color has been chosen to represent the intensity range present. Flares would not burn more than 15 minutes. All equipment will be contained in the project airplane; no ground based equipment.

Remarks: The basic equipment to be tested is now on hand. Some experimental work is being done on the aerial ground survey equipment to improve design and incorporate modifications indicated by results of BUSTER/JANGLE. These tests will permit determination of errors of equipment in the field. For this purpose, fairly extensive contaminated areas are required which are obtained only in an atomic detonation. This equipment will ultimately be used by special carrier-based aircraft to provide assault troops with information on contaminated areas which they may enter. Participation in these tests is necessary to insure that production equipment are suitable for fleet use.

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Project Number: 6.10 Title: Rapid Aerial Radiological Survey

Sponsor: U. S. Army Performing Agency: Signal Corps Engineering Laboratory

Project Officer: 2nd Lt. John R. Price, USA

Objective: To improve the techniques of making a radiological aerial survey. To provide the radiological safety organization with a radiological aerial survey.

Procedure: The rapid aerial survey will be conducted using a L-20 Liaison type plane, radiation detection instruments and a stop watch. The contamination at a given point on the ground will be determined by flying over the spot at three or more altitudes and obtaining values to plot a curve which, when extrapolated downward, will give the ground contamination distribution.

Remarks: None

[redacted]

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Project Number: 6.11 Title: Operational Training for Tactical Air Command Crews

Sponsor: U. S. Air Force Performing Agency: Air Research and Development Command, Tactical Air Command

Project Officer: Lt. Col. Ernest T. Cragg, USAF

Objective: To provide realistic operational training for TAC aircraft crews on the effects of blast, thermal and nuclear radiation that will be encountered in the delivery of atomic weapons.

To provide additional data on the temperature rise of aircraft skin while in flight.

Safe escape distances as a function of yield and delivery method have been calculated by TAC and provide the basis for present operational delivery techniques. Project 6.11 was established to provide realistic crew training within the limits of the safe escape distance calculations.

Procedures: Eight aircraft (F84's and B-45's) will be positioned at safe distance on radial headings away from the point of burst. Six cal/sq cm will be the primary factor in the positioning of the aircraft.

a. The actual positioning of the aircraft will be accomplished by dividing the area with respect to GZ point into four quadrants and then assigning different altitudes to each aircraft within a particular quadrant. This method provides the utmost in simplicity, and reflects a minimum cost to the USAF by eliminating radar requirements. The maximum amount of thermal radiation any aircraft would receive is controlled, and within the safe limits for aircraft and crews.

b. Thermal strips provided by WADC to measure the temperature rise on the aircraft skin will be installed by TAC personnel. Reduction of the data will be accomplished by WADC. The use of these thermal strips cause a requirement for knowing the exact position of each aircraft with respect to the zero point. To maintain simplicity, this exact positioning of the TAC aircraft can be determined by a photo taken at burst time by a technical photographic aircraft already provided in the area (see technical photographic requirements). The technical photographic aircraft will know its exact position, and since the TAC aircraft feet altitudes will be known, each aircraft position can accurately be determined from this photograph.

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Project Number: 6.11 (con't)

c. Aircraft of the TAC participating in UPSHOT/KNOTHOLE will stage from George Air Force Base, Victorville, California.

Remarks: None

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PROGRAM 7

LONG RANGE DETECTION

[redacted]

PROGRAM DIRECTOR

[redacted] SECRET

[redacted]

[redacted] [redacted]

Project Number: 7.1 Title: Electromagnetic Effects from Nuclear Explosions

Sponsor: Hq, USAF Performing Agency: [redacted]

Project Officer: [redacted]

Objective: To obtain further information on the characteristics of electromagnetic emanations from nuclear explosion and their relationship with bomb characteristics.

To determine the operational suitability of various techniques and equipments as a means of gaining information on foreign atomic activity.

Procedure: a. Close-in data are required; however, it is expected that these data can be obtained from Los Alamos Scientific Laboratory experiments conducted within a few miles of the test site.

b. It is planned to obtain data from the following stations of the National Bureau of Standards; Stanford University, California; Boulder, Colorado; and Sterling, Virginia. It is also expected that direction-finding equipment will be further tested by operating Sferics equipment at three or more locations at distances up to about 2000 miles from the test site.

c. If SNAPPER tests indicate that ionospheric perturbations due to atomic explosions have long range detection applications, it is expected that arrangements will be made for support of further studies.

Remarks: Results from BUSTER/JANGLE and TUMBLER/SNAPPER tests indicate that at least one electromagnetic pulse is associated with an atomic explosion, and that this pulse can be detected at long distances from the source. Results from Sferics stations during TUMBLER/SNAPPER make it appear promising for fixing approximate source location by azimuth intersections from two or more stations. There has been a beginning in the problem of determining signal characteristics and their relation to bomb characteristics.

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Project Number: 7.2

Title: Detection of Fireball Light at Distances

Sponsor: Hq, USAF

Performing Agency: [redacted]

Project Officer: [redacted]

Objective: To measure the light from an atomic explosion at distances from the test site; to test improved instrumentation; to gain additional information on the mechanism of light transmission along curvature of the earth; to determine energy released by means of curves of light intensity versus time.

Procedure: It is planned to make measurements with improved equipment to the north of the Nevada Test Site, very likely using part or all of the three stations from which measurements were made during [redacted]: Mt. Home, Idaho; Baker, Oregon; and Ephrata, Washington. In addition, if further investigations planned for the intervening months so indicate, measurements will be made with improved apparatus at greater distances. The ultimate objective is to detect the fireball light at about 1000 miles from the emitting source.

Remarks: TUMBLER/SNAPPER data indicate that the atomic bomb light was detected to a distance of 540 miles. It is hoped that certain presently untried techniques may extend the detection range.

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Project Number: 7.3

Title: Detection of Airborne Low-Frequency Sound from Atomic Explosions

Sponsor: Hq, USAF

Performing Agency: [redacted]

Project Officer: [redacted]

Objective: Measurements of the airborne low-frequency sound from the atomic explosions of operations UPSHOT and KNOTHOLE will be made at a variety of distances and azimuths from the detonation point. Data will be analyzed in order to obtain amplitude, duration, azimuth, horizontal phase velocity, and frequency spectrum of acoustic arrivals. Results will be used in interpretation of acoustic signals picked up from unknown sources during routine operation of the AEDS acoustic net.

Procedure: Standby semi-permanent acoustic stations established originally for Operations BUSTER and JANGLE and maintained for future atomic tests in the U.S. will be reactivated for UPSHOT/KNOTHOLE. Stations will be located at Oahu, T. H.: Fairbanks, Alaska; Ft. Lewis, Washington; Pyote AFB, Texas; California-Arizona Desert; Breckinridge, Kentucky; Washington, D. C.; and Belmar, N. J. Operations will cover the entire test series.

Remarks: Acoustic measurements during GREENHOUSE, BUSTER/JANGLE, and TUMBLER/SNAPPER have indicated the feasibility of acoustic long-range detection. Continued acoustic measurements during atomic tests are required in order to determine the variations to be expected in detection capabilities as a function of season, location and yield, and to establish the suitability of new acoustic equipment and techniques.

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Project Number: 7.4

Title: Seismic Measurements during Operation Upshot and Knothole

Sponsor: Hq, USAF

Performing Agency: [redacted]

Project Officer: [redacted]

Objective: To gather additional seismic data which will assist in evalnating range and reliability of seismic detection techniques for use in the Atomic Energy Detection System.

Procedure: Seismic stations will be operated at varying ranges as follows:

a. Intermediate and long distance will be covered by routine [redacted] operations, supplemented by reactivation of standby semi-permanent installations at Ft. Sill, Oklahoma and Anniston, Alabama.

b. Strong motion measurements will be included only under the following conditions:

(1) If shots are larger than any previously scheduled at Nevada;

(2) If shots are small but at different locations than previously scheduled small shots in Nevada; and

(3) Shots of any size, provided they occur over targets of rock rather than alluvium.

Data will be analyzed for times of arrival of significant phases, amplitudes, frequency content, duration and significant criteria.

Remarks: Past measurements of close-in strong motions have not covered the required variety of terrain conditions and further measurements are required to provide the data necessary to evaluate both capability of seismic detection system and the significance of future seismic signals of unknown origin. Long distance data need to be supplemented at the time of UPSHOT for a more detailed examination of the attenuation of signal with distance.

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Project Number: 7.5

Title: Calibration, Analyses of A-Bomb Debris

Sponsor: Hq, USAF

Performing Agency: [redacted]

Project Officer: [redacted]

Objective: To continue obtaining calibration data based on the determination of fission products and other nuclear properties of atomic bomb debris collected by manned aircraft close to the detonation point. In addition to the close-in sampling, samples of atomic bomb debris will also be collected at some distant point or points in order to obtain bomb debris calibration data similar to that obtained for the close-in samples.

Analytical efforts expended in the UPSHOT series will be concentrated in studying atomic bomb debris collected from exploded bombs in which the composition and mode of explosion are significantly different from those previously tested. The efforts of this program will be minimized if atomic bombs similar to previous ones tested are included in the UPSHOT series.

Procedure: Filter paper samples and gas samples of atomic bomb debris close-in to point of detonation will be required. The precise number of filter papers and gas samples required will be specified when a more comprehensive knowledge of the weapons to be tested is available. Close-in sampling is a joint Las Alamos Scientific Laboratory, AEC, and [redacted] effort. Detailed arrangements for division of samples and couriering will be arranged by mutual agreement among these organizations. Requirements for distant samples will be provided at a later date and details of sampling and couriering will be handled by [redacted]

[redacted] Technical personnel and its selected contractors will analyze the bomb debris samples for fission products, residual fissionable materials, core and tamper reaction products, and any other analyses as deemed necessary to fulfill the requirements of this program.

Remarks: Previous analyses of bomb debris have indicated that relations between fission products and between the core and tamper reaction products have provided useful information in evaluating the type of atomic bomb tested with respect to composition and in estimating the efficiency of the explosion. A sufficient amount of these data have been compiled to indicate the desirability for continuation of this calibration work to

obtain better quantitative relations with a subsequent more precise interpretation of the data obtained. Results of previous atomic explosions, particularly the undergrounded and surface shots of the JANGLE series, have indicated that the environment of the explosion, that is, a ground, tower or air-burst, introduced additional variables in the analytical data sought. It is thus necessary that these iables effects be further studied in order to more clearly establish the effects of these variables on the end results.

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PROGRAM 8

THERMAL MEASUREMENTS AND EFFECTS

LT R G PRESTON, USN

PROGRAM DIRECTOR

[redacted]

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Project Number: 8.1 Title: ~~Aircraft~~ Structures Test

Sponsor: U. S. Air Force Performing Agency: Wright Air Development Center

Project Officer: Capt. George T. James, USAF

Objective: The objectives of this project are: To determine the separate and coupled effects of blast and thermal phenomena on typical, modern aircraft structures and basic structural members as related to the thermoelastic problem; and to obtain additional information on the velnerability of parked aircraft.

Procedure: The necessary data will be obtained by exposure of instrumented test articles, some exposed to thermal radiation only, some to blast only, some to both blast and thermal. Panels with various stringer spacings will be instrumented with Temp Tapes and protected from the blast to determine the threshold of permanent thermal buckles. Aircraft will be exposed to supplement data obtained on aircraft vulnerability by Project 3.1 Operation TUMBLER/SNAPPER.

Remarks: This project results from a continuing Research and Development program to develop design criteria for aircraft of the future. This project is directed by the Structures Branch of Aircraft Laboratory of WADC, which has directed projects in Operations GREENHOUSE, BUSTER/JANGLE, and TUMBLER/SNAPPER, all a part of the continuing R&D programs and leading to this project. Achievement of the objectives of this project at this time is very important as the tactical and strategic applications weapons present serious problems concerning aircraft structures. The data obtained will indicate the separate magnitude of stresses due to thermal and blast inputs. The data will be used to develop design criteria for new aircraft structures. This project will participate on one tower shot and two airdrops in Yucca and on KNOTHOLE 1 and 2.

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Project Number: 8.2

Title: Measurement of Total Thermal Radiation by Means of Radiation Pressure Phenomenon

Sponsor: U. S. Air Force

Performing Agency: Air Force Cambridge Research Center

Project Officer: Dr. Marcus D. O'Day, Civ.

Objective: To measure the intensity of total radiation as a function of time with the vacuum microphone.

Procedure: It is intended to locate several thermal radiation detectors on the ground at various distances from ground zero. The sensitive element of the detector is an extremely light, highly reflective metallic diaphragm with an area of approximately one square centimeter. A rigid metallic disk is located in close proximity to the diaphragm. The disk and the diaphragm constitute an electrical capacitance across which is placed an inductance, thus forming a parallel resonant circuit. A remote recording apparatus will be located at a suitable manned site and will receive and record the signals generated by the instrument. This project represents the final field evaluation of this type of thermal radiation instrument since preliminary information on its performance was obtained at TUMBLER/SNAPPER.

Remarks: This project will participate in all shots.

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Project Number: 8.4 Title: Attenuation of Thermal Radiation

Sponsor: AFSWP [redacted] Performing Agency: Army Chemical Center

Project Officer: Mr. Elmer H. Engquist, Civ.

Objective: The objective of this project is to evaluate the effectiveness of oil fog smoke screens in reducing the intensity of thermal radiation from an atomic bomb incident on a target.

As an important secondary objective the goniometry of the radiation received within the screen will be determined to evaluate the effect of scattering of thermal radiation within the oil fog smoke screen.

Procedure: A standard oil fog smoke screen will be established over an instrumentation line running from 2000 feet to 6000 feet from ground zero in a direction perpendicular to the anticipated low level wind direction. This line will be instrumented under the screen with thermal radiation measuring instrumentation capable of reading the total flux received in calories per sq. cm. Two types of instrumentation will be used. Naval Material Labbratory thermal sensitive papers and foils will be distributed to furnish statistical data on the radiation received. This instrumentation will be non-electronic and inexpensive and will permit variations which occur in the data as a result of variations in the smoke screen to be averaged. The second type of instrumentation will be placed at a minimum of eight stations from 2000 to 6000 feet from ground zero as a primary standard. Three types of instrumentation are currently under consideration and/or development for these stations and will be true black body standards. A second instrumentation line on the opposite side of ground zero will be established to measure the radiation received at similar distances from the detonation without smoke present. Direct comparison of the data will permit the calculation of the attenuation coefficient of the smoke screen for atomic bomb thermal radiation. It is extremely important to this evaluation to control the meteorological conditions at shot time to provide an adequate, uniform screen. It is desired that a surface wind of 6 to 10 mph, and wind direction 70° to 110° from the instrumentation line control at shot time.

Remarks: The U. S. Naval Radiological Defense Laboratory has made an initial investigation of the possibilities of providing thermal protection through the use of smoke screens. As a part of this program the Chemical Corps and USNRDL measured the attenuation of the sun's

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Project Number: 8.4 (con't)

radiation by a smoke screen. The subject of thermal attenuation by smoke screen was also studied by the Project East River Group of the Associated Universities, Inc., under Dr. A. J. Hudgins, University of California Radiation Laboratory with the publication of a report "Thermal Radiation Attenuating Clouds (TRAC)". Dr. Hudgins has also previously conducted theoretical and some laboratory studies of the potential shielding effect of smokes. The results of these studies indicate that sufficient attenuation of thermal radiation can be accomplished through the use of smoke to warrant a field test. The Chemical Corps is currently prosecuting the theoretical and meteorological program r ecommended in the TRAC report, both studies to have a completion date of 1 February 1953 so that the results may be available for planning the Operation KNOTHOLE evaluation. An early evaulation of smoke is desired against an operational air drop atomic weapon. Data on the total thermal flux received with and without smoke present will be obtained to permit an evaluation of the protection afforded by the smoke screen. This project will participate on KNOTHOLE 1 and 2.

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Project Number: 8.5

Title: Degrees and Extent of Burns Under Service Uniforms

Sponsor: U. S. Army

Performing Agency: Quartermaster Research and Development Laboratory

Project Officer: Dr. J. Fred Oesterling, Civ.

Objective: To provide information on the protective value of standard Armed Forces clothing ensembles against the thermal effects of the bomb, which can be integrated with their protective value against other flame and thermal agents, being studied in parallel programs, and their use for environmental protection.

Procedure: Standard clothing assemblies will be tested simultaneously on dummies and live animals in an integrated study to determine what order of protection such ensembles afford against selected thermal energies. Both dummies and test animals will be exposed at stations of varying thermal energies. Measurement of thermal transmission will be based in part upon the use of thermal indicators in back of or between the layers of protective barriers. Thermocouple devices will also be used to obtain time temperature readings. These data will be correlated with degree of burn on test animals as determined by medical examination.

Remarks: QM test panels exposed at Operations RANGER and BUSTER have indicated the effects of variations in reflections, fabric thickness and special treatments. In many cases the protection is inadequate even at intensities below those critical for damage to the fabrics. Moreover, the energy transmitted to the backing seems to depend in a rather complicated manner on the spacing of the fabric from the backing and on the intensity; and there are not sufficient data over a range of energies to indicate the important factors. The data obtained will be used as a basis for future laboratory work in the study and development of protective clothing barriers against thermal radiation. This project will participate in KNOTHOLE 1 and 2.

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Project Number: 8.6

Title: Thermal Effects on Clothing Materials, Panel Tests

Sponsor: U. S. Army

Performing Agency: Quartermaster Research and Development Laboratory

Project Officer: Dr. J. Fred Oesterling, Civ.

Objective: To test fabric assemblies on panels simultaneously with the tests on dummies and animals, in order to relate the results obtained by this technique to results obtained with clothing, as well as to experience previously obtained in field tests, with respect to transmissions, conductance, reflectance, absorption and dissipation of heat through fabric systems.

Procedure: Single and multiple layers of fabrics will be exposed as 9"x12" panels on metal racks, positions at various distances from ground zero to yield a variety of thermal energies. Thermal indicators will be placed between layers of fabrics and back of the test fabrics. Time-temperature recording devices will be used in conjunction with some of the panel tests.

Remarks: Exposure of test fabrics of items of clothing at previous atomic tests, as well as studies of the thermal value of textiles in various laboratories, has not as yet provided a body of well correlated data. This test is designed primarily to provide related data as a basis for interpretation of laboratory results and correlation with the effects of other flame and thermal agents. Insofar as clothing is concerned, it involves the integrated study of the thermal protection afforded by fabrics exposed as panels, fabrics exposed on dummies and the same fabric systems exposed on animals. This project will participate in KNOTHOLE 1 and 2.

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Project Number: 8.7

Title: Protective Value of Tentage Against Thermal Radiation

Sponsor: U. S. Army

Performing Agency: Quartermaster Research & Development Laboratories

Project Officer: Dr. J. Fred Osterling, Civ

Objective: To determine what protection Armed Services standard tents provide against thermal radiation.

Procedure: A number of types of standard tents will be exposed at stations of varying thermal energies. The tents will be oriented in predetermined positions and will be equipped with thermal indicators at different points within the tent. These data will be analyzed with regards to its possible bearing on the following questions:

(1) How much thermal energy penetrates through the various fabric systems when exposed under fixed conditions as panels as compared with when they are used as clothing?

(2) What is the resistance of single and multiple fabric layers to thermal destruction when exposed on panels compared to corresponding clothing ensembles?

(3) What effect does spacing have on protective barriers in fabric panels as compared with their use in clothing?

(4) Does conductance play a significant part in the transfer of heat through fabric systems?

(5) With a given series of like fabrics having variable reflectance both in the visible and infra-red, what arrangement of multiple layers afford the best protective barrier? (Should the inner layer next to the skin be highly reflective, such as whit, or have a low reflectancy and high absorbency?)

(6) Are there significant differences for various parts of the visual spectrum?

Remarks: This project will participate in KNOTHOLE 1 and 2.

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[redacted]

Project Number: 8.9 Title: Effects of Thermal Radiation on Materials

Sponsor: AFSWP [redacted] Performing Agency: Naval Material, New York Naval Shipyard

Project Officer: Mr. Thomas I. Monahan

Objective: To determine the characteristics of the thermal radiation emitted during nuclear detonations, particularly:

(a) The effective thermal radiation dosage and the spectral distribution of the effective flash as a function of bomb yield distance and time.

(b) The amount of energy transferred through one or more layers of clothing.

(c) The influence of material parameters on the degree and extent of thermal damage.

(d) The effect on a skin simulant for correlation with laboratory studies.

Procedure: Five major stations will be established, on prefabricated racks, at operationally pertinent distances from ground zero. The spectrum of the effective irradiance will be measured using passive indicators. The heat transfer by conduction and re-radiation from the back surface of the cloth will be measured by passive indicators in the form of gelatine, papers, or the like, and active indicators in the form of thermocouples and calorimeters. The temperature as a function of time of various materials used in the laboratory in the study of a skin simulant will be made. A timed shutter mechanism will be employed to limit the exposure of individual material specimens to discrete times. The exposed materials will be sent to the laboratory, after initial evaluation, for complete investigation. Small sensitive thermocouples connected to Heiland recorders will be employed for temperature-time measurements.

Remarks: These data are required in connection with the laboratory studies of the effects of thermal radiation on materials. The thermal radiation pulse, that is the variation of intensity with time, does not necessarily indicate the effective energy to which a material reacts when irradiated, inasmuch as the fire ball is cooling during most of the exposure. The measurements at RANGER and GREENHOUSE indicated that the time of exposure

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Project Number: 8.9 (con't)

as indicated by materials is somewhat shorter than that recorded by instruments. As part of the Naval Material Laboratory BUSTER studies, a limited investigation on the effective time of irradiation was made, through the exposure of sets of typical materials and the use of a shutter mechanism which limited the exposure of individual material specimens to discrete times. It is proposed to continue this study, with particular emphasis on the effects of the level of the incident energy as produced by bombs of different yields. This project will participate in two Yucca airdrops and KNOTHOLE 1 and 2.

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Project Number: 8.10 Title: Measurement of Basic Characteristics of Thermal Radiation

Sponsor: AFSWP Performing Agency: U. S. Naval Radiological Defense Laboratory

Project Officer: Dr. Andrew Guthrie, Civ.

Objective: a. To determine the characteristics of the thermal radiation emitted during an atomic bomb detonation including total energy, rate of delivery of energy, and spectral distribution in three broad bands (ultraviolet, visible, infra-red) and the variation of certain of these characteristics with such parameters as time, distance, field of view, and the presence of obscuring matter.

b. To determine the albedo of the surface over which the bomb is detonated and the interrelation with thermal measurements and effects.

Procedure: Multiple instrument stations will be located at various distances from ground zero selected to cover a wide range of thermal energies. The total energy will be measured with a recording disc calorimeter having a time resolution of 20 ms. The intensity - time variation will be determined from the calorimeter curve and independently checked using the MIT-intensity device. Spectral distribution will be determined by means of selected filters covering the calorimeter element. Additional calorimeters will be used to determine the variation of the characteristics with various parameters, as indicated above. Albedo measurements will be made before and during the detonation. Electrical recording will be accomplished for both the calorimetric and intensity instruments by standard recording instruments located in well-protected shelters.

Remarks: This project will participate on two airdrops in Yucca and on KNOTHOLE 1 and 2.

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Project Number: 8.11a

Title: Initiation and Persistance of Primary Fires (Structures and Interiors of Structures)

Sponsor: AFSWP

Performing Agency: Forest Products Laboratory, FS, USDA

Project Officer: Mr. H. D. Bruce, Civ

Objective: To ascertain the ignition and persistence of primary fires in inflammable materials associated with combustible man-made structures.

Procedure: The procedure will be to expose inflammable materials commonly found in urban areas to radiation of 20 calories/cm^2 and less to learn what thermal energies cause ignition in each test material, the effects of the blast wave on persistence of primary fires, and the seriousness of each ignited material as a source of spreading fire to combustible structures.

Remarks: This project is a continuation of Project 8.5 of Operation TUMBLER/SNAPPER in which combustible structures were exposed. The K/U Operation will be utilized for exposure of inflammable materials in association with structures. The test results will be utilized to confirm or correct laboratory data on the ignitability of materials and will ultimately serve as a basis for civil defense planning. This project is supplementary to Project 8.11b (q.v.) the final report for the two projects will be co-authored by the two project officers. This project will participate in two airdrops in Yucca and KNOTHOLE 1 and 2.

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Project Number: 8.11b

Title: Initiation and Persistence of Primary Fire (Ignitable Litter)

Sponsor: AFSWP

Performing Agency: California Forest and Range Experiment Station, FS, USDA

Project Officer: Dr. Keith Arnold, Civ

Objective: 1. To determine minimum thermal energies required to ignite transient external kindling fuels found in urban areas.
2. To study blast-wave effect on persistence of ignition.
3. To provide field data against which laboratory source tests could be scaled.

Procedure: Kindling fuels will be exposed in trays 2 ft square and 4 inches deep. Cardboard boxes with and without paper will be exposed in their natural form and held in place by 2-inch mesh chicken wire. Fence sections will be exposed at one station with kindling fuel accumulations arranged at their bases.

All fuel samples will be exposed at each thermal station, 5,000, 6,000, 7,000, 8,000, 9,000, 10,000, 11,000, 13,000, and 15,000 feet from ground zero on Shot 1 and at the first seven of these stations on Shot 2. Fence sections will be erected only at the 8,000 foot station on Shot 1, Fuel moisture samples will be taken at the control station at shot time.

Remarks: Project 8.11b is part of a research program which seeks to predict the probable number of primary ignitions that may result from atomic explosions in transient, external kindling fuels in urban areas. Sample surveys are now being made to identify transient external fuels in urban areas and to measure their frequency distribution. Ignition energies required to ignite these fuels will be determined by laboratory source prior to Operation KNOTHOLE. Preliminary planning is based on results obtained from Project 2.2 Operation BUSTER and from Project 8.1 Operation SNAPPER. This project is supplementary to Project 8.11a (q.v.) and the final report for the two projects will be co-authored by the two project officers. This project will participate in two airdrops in Yucca and KNOTHOLE 1 and 2.

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Project Number: 8.12a

Title: Measurement of Velocity of Sound

Sponsor: AFSWP

Performing Agency: U. S. Navy Electronics Laboratory

Project Officer: Mr. H. C. Silent, Civ

Objective: To determine the velocity of sound near the surface at the time of transit of the shock wave

Procedure: A sound velocity meter of U. S. Navy Electronics Laboratory design similar to that used on TUMBLER/SNAPPER will be used to give sound velocity measurements at approximately 1/100 second intervals at a series of stations in the region of overpressures in excess of 3#/in.2. An attempt will be made to measure the particle velocity in the shock wave at about the 10#/in.2 range. Data will be recorded at a relatively safe distance on equipment mounted in an automotive van. A modulated sound wave will be sent across an air gap. The relative phases of the transmitted and received waves will be compared to determine the velocity of the sound.

Remarks: This project will participate in two airdrops in Yucca and KNOTHOLE 1 and 2.

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Project Number: 8.12b

Title: Thermal Effects Measurements

Sponsor: AFSWP

Performing Agency: David Taylor Model Basin

Project Officer: Mr. George Cook, Civ.

Objective: To investigate the nature of precursor pressures resulting from the thermal radiation from an atomic explosion.

Procedure: Three different test surfaces at each of two stations will be instrumented with high resolution pressure gages along with a reference gage at ground level. The 10 ft. by 10 ft. test surfaces will be oriented normal to the incident thermal radiation. These surfaces will have low conductivity and high surface absorbtion. One surface will "popcorn" and smoke. The second will have the same characteristics without "popcorning" and smoke. The third surface will be a replica of the local terrain. The two stations will be located in the region of precursor influence and outside the normal precursor generation region.

Remarks: None

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PROGRAM 9

TECHNICAL PHOTOGRAPHY

MAJ WR GREER, USA

PROGRAM DIRECTOR

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Project Number: 9.1 Title: Technical Photography for the Support Operation UPSHOT/ KNOTHOLE

Sponsor: DWET Performing Agency: EG&G, USA Signal Corps and Lookout Mountain Laboratory

Project Officer: Maj. William R. Greer, Jr., USA Signal Corps

Objective: The objective of this project is to furnish data as may be required by other projects by means of technical photography.

Procedure: It is proposed to record on photographic films and papers data from an atomic explosion which cannot be recorded or obtained by other means of instrumentation. Such data will include the recording of the precursor wave, the triple point, effects on structures, effects on various materials and small animals.

To obtain such data varied types of cameras and films will be employed, such as oscillograms, high speed motion picture photography (up to 3000 frames/second), normal speed motion picture photography and still photography. Both black and while and color films will be used.

Some projects will require photographic coverage during the actual explosions while other projects will require pre and post shot photography to determine effects and other data.

Remarks: In addition to the objective of this project, the Program Director will be responsible for the issue, storage, direction of processing and distribution of all photographic coverage. Also the registration of cameras, films and papers will be controlled by the Program Director.

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Project Number: 6.12

Title: Determination of Height of Burst and Ground Zero

Sponsor: U. S. Army

Performing Agency: Army Field Forces Board #1
Evans Signal Lab

Project Officer: Lt. Col. Roland V. Tiede, USA

Objective: To test methods proposed for tactical determination of ground zero and height of burst.

The proposed methods are three in number and involve techniques emplying acoustic, flash ranging, and radar equipment. These equipments employed will represent items which are now or are expected to be standard field force equipment.

Procedure: The operational procedures for the three types of experiments are as follows:

SOUND: Base lines and arrays of microphone and geophones will be placed about 10 miles from the burst in surveyed locations. These equipments will record time arrivals of the sound of burst through the ground and through the air; time differences in the energy arrival through the different media will be a direct measure of height. The azimuth of the sound source will be determined by Sound Ranging Techniques. This experiment may not be successful in tower shots, however, no complications are foreseen in air drops or howitzer shots.

FLASH RANGING: Rapid process cameras located on surveyed base lines will photograph the burst. From the photograph and survey data, the position can readily be determined by triangulation. This method should be successful on all types of shots.

RADAR: A mortar tracking type of radar is expected to be placed behind the howitzer to track the missle and record location of burst. This method will have prime usefulness for howitzer type shots, however, efforts will be made to track air drops also. Tower shots will not be used for this technique.

Remarks: None

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